BIOLOGICAL RESPONSE TO REDUCED SEA ICE IN THE PACIFIC ARCTIC REGION

Workshop held at the Pacific Marine Environmental Laboratory, Seattle, WA, USA
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WORKSHOP SUMMARY

The Chukchi Sea in the Pacific Arctic Sector (defined as the spatial region from the northern Bering Sea to the Arctic Ocean is currently experiencing the largest regional changes in sea ice extent, with potential long-range changes to the Arctic ecosystem. Emerging questions as to what biological organisms and processes are undergoing change, what might happen to this biological component with future climate warming, and how to track these changes in an observational network mode brought a group of experts to a workshop in Seattle, Washington, USA during May 6-8, 2009. The US National Oceanic and Atmospheric Administration (NOAA) Arctic Program Office sponsored the workshop entitled "Biological Response to Reduced Sea Ice in the Pacific Arctic Region".

Major findings from the workshop were: 1) an observed asymmetry of the timing of sea ice loss, being more important spatially to biology in autumn than spring due to a larger impact on biological growth rates in summer, 2) that sea ice trends are more dramatic and unidirectional north of Bering Strait in summer and fall; however, biological shifts are occurring everywhere due to the critical role of sea ice as habitat for organisms as well as its influence on hydrographic conditions tied directly to species growth and distributions, and 3) common biological changes being observed in changing ice covered waters include: a) changes in species composition, b) changes in the range and abundance of species, including a northward expansion from lower to higher tropic organisms, and c) impacts on prey growth rates and productivity that directly cascade to life cycles of higher topic level organisms.

The potential impacts on biological productivity in current ice-associated regions with climate change are key. Critical limiting factors are spatially heterogeneous (sea ice/light, nutrients, temperatures, and prey availability). The workshop participants identified the need to look at smaller focal regions with a consistent suite of physical and biological measurements to be able to compare across systems. For example, the idea that increased primary production will result from decreased sea ice due to larger areas of open water for greater periods is under debate due to eventual nutrient limitation and increased storm events that could break down the required stratification for increased productivity. Changes in species composition of phytoplankton, zooplankton, benthic fauna (the latter two as lower trophic prey) and changes in fish, bird, and marine mammals (as higher trophic predators) are directly linked to underlying shifts in physical forcing parameters seen at larger scales (changes in sea ice extent, seawater temperature, and freshwater content).

Although recent major environmental changes are well documented in the physical domain of the Arctic, such as extreme retreat of summer sea ice in 2007 and beyond, large uncertainties remain for the biological domain. North of Bering Strait, recent reduction in sea ice extent has been seasonally asymmetric, with minimal changes in sea ice cover during spring and early summer, a major retreat beginning in July, with sea ice formation delayed until late autumn. The effect of this seasonally asymmetry on ocean primary production in the western Arctic is equivocal, with satellite images showing higher summer chlorophyll fluorescence in 2007 compared to 2003 and 2006, but no trend in chlorophyll-a concentration over the years 1998-2008. On-ice sampling suggests ice-algal production has been largely unaffected. These observations, when combined with climate projections of future sea ice loss, suggest little trend in primary production into the immediate future. However, large biological changes are occurring at higher trophic levels: shifts in zooplankton species, reduced habitat for Arctic cod,

and loss of sea ice as a platform for some marine mammals such as ringed and bearded seals, walrus and polar bears that are important to subsistence hunting by local inhabitants.

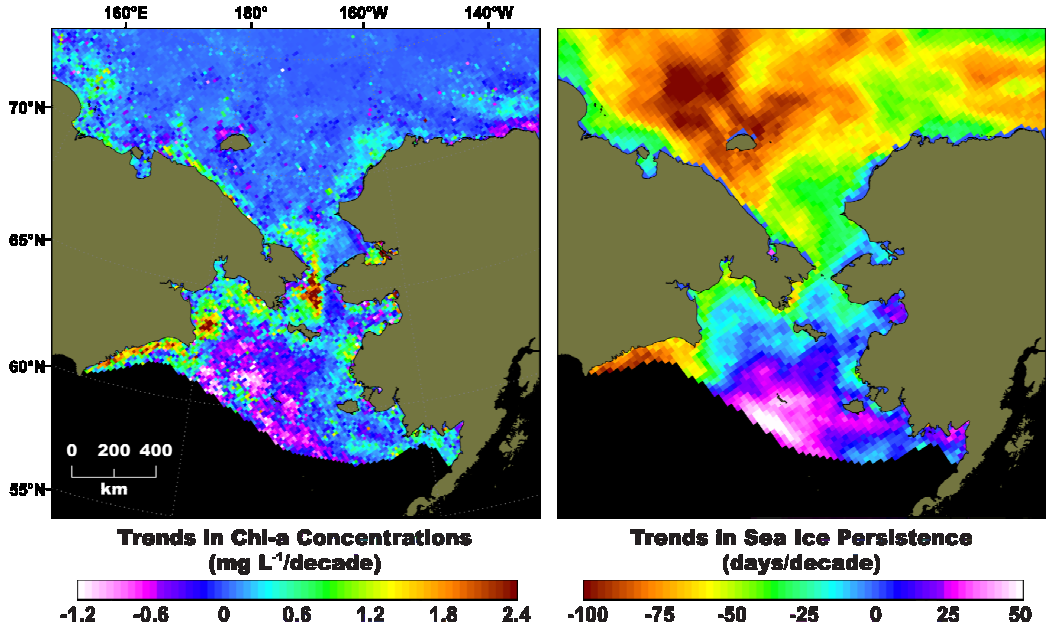

Figure 1- Trends in SeaWIFS-derived chlorophyll-a concentrations and SSM/I passive microwave-derived annual sea ice persistence over the years 1998-2008 (Appendix D, Karen Frey abstract).

A consensus on recent biological changes in the Arctic and potential future shifts in ecosystems due to climate change was reached during this workshop. The participants concluded that there was a need for a "Distributed Biological Observatory, DBO" that would include consistent observations (methods and technology) to evaluate whether species are indeed extending spatially and whether their composition are changing, measured both over varying time and space scales (Grebmeier et al. 2010). The three major areas (northern Bering Sea, Chukchi Sea, and Beaufort Sea) were identified as key observatory sites based on their (a) high productivity, (b) biodiversity, (c) highest observed current rates of biological change, and (d) their pivotal geographic areas in the Pacific-influenced Arctic system. An increasing number of multi-national ship operations in the Pacific sector could service a "Distributed Biological Observatory" a number of times annually where a minimal number of standard measurements could be collected as part of a coordinated network of international scientists, with national process studies undertaken specific to the sub-regions of interest.

The following workshop report outlines the direction and discussions of participants during the workshop that culminated in the development of the DBO concept (Grebmeier et al. 2010) and ongoing international pilot program (see DBO workshop http://ww.noaa.gov/dbo). Appendices A-E include the information provided to the workshop participants: Appendix A: Letter to Attendees from Workshop Conveners, Appendix B. Primer for reduction of sea ice and biological change (J. Grebmeier), Appendix C. Final workshop agenda, Appendix D. Participant Abstracts, and Appendix E. Participant List.